

GREAT FALLS MALMSTROM AFB

CASCADE COUNTY

Malmstrom Air Force Base is located on the eastern side of Great Falls at 47 31 12 N and 111 10 12 W (Site No. 14 on Map II-1). Elevation at the base is 3,465 feet. Meteorological data have been collected at this site for many years by the United States Air Force.

These data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in anemometer height, the data set was broken into three parts for analysis: January 1, 1949, through May 31, 1953; March 1, 1954, through February 28, 1958; and April 1, 1958, through November 30, 1968. Only data from the most recent of these periods were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for Malmstrom Air Force Base consists of data summaries of observations made every third hour from April 1, 1958, through November 30, 1968. The anemometer was mounted on a ground mast at a height of 4.6 meters. The site is representative of lower lying areas in the vicinity of Great Falls.

Average annual wind speed was 8.7 miles per hour. Monthly average wind speeds ranged from 5.6 miles per hour in July to 10.7 miles per hour in January.

Average annual wind power was 106.0 watts/m². Average monthly wind power varied from 33.0 watts/m² in July to 175.0 watts/m² in January.

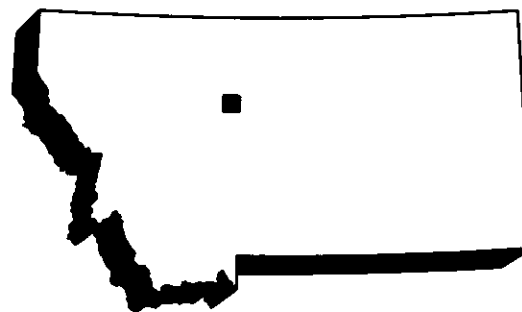


Table IV - 15
Monthly Wind Speed Distribution
CASCADE COUNTY - GREAT FALLS MALMSTROM AIR FORCE BASE
04/01/58 - 11/30/68

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	12.4	10.8	12.0	9.9	12.8	16.1	19.7	15.8	15.6	12.1	13.3	12.4	13.7	CALM (<0.5)
1.1- 3.1	5.7	5.2	5.9	5.9	6.9	8.0	10.4	8.3	7.6	5.1	5.4	6.2	6.8	0.5- 1.4
3.4- 5.4	10.4	10.9	13.2	12.9	16.3	20.2	22.8	20.5	16.7	11.6	10.4	11.6	14.9	1.5- 2.4 S
S 5.6- 7.6	11.2	13.8	14.4	14.8	16.4	17.1	18.4	18.1	17.2	13.1	12.8	13.2	15.1	2.5- 3.4 P
P 7.8- 9.8	10.6	11.9	12.3	13.9	13.2	12.9	11.9	13.1	13.3	13.3	10.7	11.5	12.4	3.5- 4.4 E
E 10.1-12.1	9.9	11.7	10.9	11.7	10.0	9.5	8.2	9.8	9.7	11.9	10.6	10.2	10.3	4.5- 5.4 E
E 12.3-14.3	9.6	9.1	9.3	8.9	7.8	6.6	3.7	6.0	6.2	9.2	9.8	8.5	7.8	5.5- 6.4 D
D 14.5-16.6	7.4	7.2	7.1	7.2	5.8	3.8	2.2	3.5	4.7	7.6	8.2	7.2	5.9	6.5- 7.4
16.8-18.8	7.1	6.4	5.4	5.2	4.4	2.3	1.4	2.4	3.5	6.2	6.7	6.4	4.7	7.5- 8.4 M
M 19.0-21.0	5.3	4.8	4.1	3.5	2.2	1.6	0.8	1.0	2.1	3.8	4.2	4.3	3.1	8.5- 9.4 E
I 21.3-23.3	4.3	3.4	2.9	3.0	2.1	1.1	0.3	0.8	1.7	2.8	3.3	3.4	2.4	9.5-10.4 T
L 23.5-25.5	2.3	1.8	1.2	1.2	0.9	0.4	0.1	0.4	0.7	1.2	1.7	2.0	1.1	10.5-11.4 E
E 25.7-27.7	1.7	1.2	0.6	0.9	0.5	0.3	0.1	0.2	0.4	0.9	1.2	1.3	0.8	11.5-12.4 R
S 28.0-30.0	1.2	0.9	0.5	0.7	0.4	0.1	0.0	0.2	0.2	0.7	0.8	1.0	0.6	12.5-13.4 S
/ 30.2-32.2	0.6	0.3	0.1	0.2	0.1	0.0	0.0	0.0	0.1	0.3	0.4	0.3	0.2	13.5-14.4 /
H 32.4-34.4	0.3	0.3	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.3	0.1	14.5-15.4 S
O 34.7-36.7	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	15.5-16.4 E
U 36.9-38.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5-17.4 C
R 39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5-18.4 O
41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4 D
45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE														
SPEED (MPH)	10.7	10.3	9.4	9.6	8.3	6.9	5.6	6.7	7.6	9.8	10.3	10.1	8.7	
AVERAGE														
SPEED (M/SEC)	4.8	4.6	4.2	4.3	3.7	3.1	2.5	3.0	3.4	4.4	4.6	4.5	3.9	
AVERAGE														
WIND POWER	175.0	150.0	114.0	120.0	87.0	55.0	33.0	51.0	76.0	126.0	150.0	148.0	106.0	
(WATTS/M**2)														

ANEMOMETER HEIGHT = 15.0 FEET = 4.6 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

GREAT FALLS NWS AIRPORT

CASCADE COUNTY

Great Falls International Airport is located about 4 miles southwest of Great Falls at 47 28 48 N and 111 22 12 W (Site No. 15 on Map II-1). Elevation at the airport is 3,688 feet. Meteorological data have been collected at this site for many years by the National Weather Service.

The site is located on a high, exposed bench between the Sun River valley to the north and the Missouri River valley to the south and east. The bench is occupied by the airport, by housing developments, and by farmland. Interstate Highway 15 runs past the site. Great Falls is an important communications and electric power generation center. It also is a major center of aviation, both commercial and military (at Malmstrom Air Force Base).

The data, primarily collected for aviation and weather forecasting uses, consist of short-term (5 minutes or less) averages of wind speed and wind direction, as well as other meteorological parameters. Data were gathered once per hour. The data have been analyzed by Battelle Pacific Northwest Laboratories. Because of changes in anemometer height and reporting intervals, the data set was split into three parts for analysis: January 1, 1948, through February 2, 1959; February 3, 1959, through December 31, 1964; and January 1, 1965, through December 31, 1978. Only data from the most recent of these periods were selected for inclusion in the *Montana Wind Energy Atlas*.

The data set for the Great Falls airport consists of data summaries of observations made every third hour from January 1, 1965, through December 31, 1978. The anemometer was mounted on a ground mast at a height of 6.7 meters. The site is representative of the higher, more exposed areas around Great Falls.

Average annual wind speed was 11.9 miles per hour. Average monthly wind speeds varied from 9.4 miles per hour in July to 14.8 miles per hour in December.

Average annual wind power was 183.0 watts/m². Monthly average wind power ranged from 77 watts/m² in July to 324 watts/m² in December.

Average seasonal wind speeds were 9.8 miles per hour in summer, 11.9 miles per hour in spring, 12.2 miles per hour in autumn, and 13.9 miles per hour in winter. During the summer, the highest average wind speeds occurred during the late afternoon. During all other seasons, the highest average wind speeds occurred in early to mid-afternoon. The lowest average wind speeds occurred about 0600 MST during spring and summer, around 0300 MST in autumn, and from 2100 to 2400 MST in winter. Diurnal range of average wind speed was nearly equal for all seasons, except for the winter.

Winds were most common from the south-southwest through west-southwest; they blew from this sector nearly half the time. Winds from the southeast through south-southeast were least common. By direction, the average wind speeds ranged from 6.5 miles per hour for winds from the southeast to 15.7 miles per hour for southwesterly winds. The strongest winds blew from the prevailing wind directions.

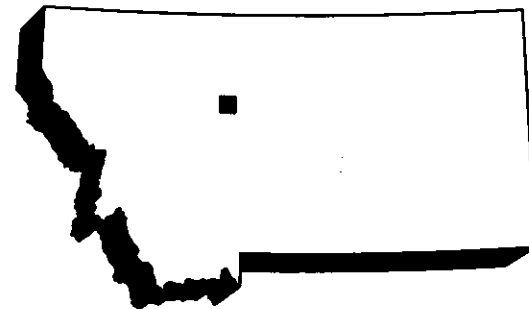


Table IV - 16
Monthly Wind Speed Distribution
CASCADE COUNTY - GREAT FALLS NWS AIRPORT
01/01/65 - 12/31/78

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM (<1.1)	2.2	2.3	2.3	1.7	1.9	1.8	1.8	1.7	1.5	1.2	2.4	1.8	1.9	CALM (<0.5)
1.1- 3.1	2.0	1.2	2.0	1.9	1.6	2.0	1.2	1.4	1.1	0.8	2.1	1.4	1.6	0.5- 1.4
3.4- 5.4	11.3	8.6	9.0	9.3	10.3	11.4	12.5	11.0	10.2	6.9	7.9	7.9	9.7	1.5- 2.4 S
S 5.6- 7.6	13.7	13.8	13.6	13.9	17.7	18.1	24.3	23.5	19.3	14.2	12.8	11.1	16.4	2.5- 3.4 P
P 7.8- 9.8	11.1	12.3	13.8	16.8	17.8	20.2	24.4	23.3	21.0	15.7	13.1	11.1	16.7	3.5- 4.4 E
E 10.1-12.1	10.4	11.8	13.4	15.3	16.4	16.0	14.5	16.0	15.9	14.8	13.4	11.0	14.1	4.5- 5.4 E
E 12.3-14.3	8.6	10.5	10.2	10.9	9.3	9.5	7.9	8.4	10.4	11.0	10.0	9.2	9.6	5.5- 6.4 D
D 14.5-16.6	7.7	9.6	9.4	8.9	8.4	6.8	5.1	5.7	6.8	11.3	8.4	8.3	8.0	6.5- 7.4
16.8-18.8	8.2	8.0	7.9	8.1	6.1	5.4	3.8	3.8	5.8	8.5	8.5	9.8	7.0	7.5- 8.4 M
M 19.0-21.0	6.3	6.9	5.8	4.8	4.4	3.4	1.8	2.1	3.5	4.8	6.3	7.6	4.8	8.5- 9.4 E
I 21.3-23.3	5.9	5.3	4.6	3.7	2.7	2.6	1.2	1.3	2.0	3.8	5.7	6.2	3.7	9.5-10.4 T
L 23.5-25.5	3.1	2.9	2.6	1.6	1.1	1.1	0.4	0.7	1.1	2.8	2.6	4.1	2.0	10.5-11.4 E
E 25.7-27.7	2.8	2.7	1.9	1.4	1.0	0.7	0.5	0.6	0.9	1.4	2.3	3.4	1.6	11.5-12.4 R
S 28.0-30.0	2.5	1.9	1.8	0.9	1.0	0.6	0.2	0.5	0.4	1.6	2.3	3.0	1.4	12.5-13.4 S
/ 30.2-32.2	1.7	1.0	0.5	0.2	0.3	0.2	0.1	0.1	0.1	0.6	1.1	1.7	0.7	13.5-14.4 /
H 32.4-34.4	1.0	0.6	0.6	0.4	0.1	0.1	0.1	0.1	0.0	0.3	0.4	1.3	0.4	14.5-15.4 S
O 34.7-36.7	0.5	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.4	0.2	15.5-16.4 E
U 36.9-38.9	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.1	16.5-17.4 C
R 39.1-41.2	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	17.5-18.4 O
41.4-43.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	18.5-19.4 N
43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	19.5-20.4 D
45.9-56.8	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	20.5-25.4
57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4
68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4
79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4
>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4
AVERAGE														
SPEED (MPH)	13.6	13.2	12.8	11.9	11.0	10.5	9.4	9.6	10.5	12.8	13.2	14.8	11.9	
AVERAGE														
SPEED (M/SEC)	6.1	5.9	5.7	5.3	4.9	4.7	4.2	4.3	4.7	5.7	5.9	6.6	5.3	
AVERAGE														
WIND POWER	298.0	247.0	217.0	163.0	133.0	113.0	77.0	84.0	111.0	192.0	241.0	324.0	183.0	
(WATTS/M**2)														

ANEMOMETER HEIGHT = 22.0 FEET = 6.7 METERS

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 17
Percentage Frequency Summary For Wind Speed
CASCADE COUNTY - GREAT FALLS NWS AIRPORT (WINTER)
01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	AV SPEED (MPH)	AV SPEED (M/SEC)
		WIND SPEED (M/SEC)																	
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	3.0	1.6	10.5	12.2	12.2	11.3	10.1	7.7	9.3	6.7	5.9	2.9	2.4	2.1	0.9	1.3	13.1	5.9
	6	2.4	1.4	9.8	13.0	11.3	11.9	9.4	8.9	9.6	6.6	4.7	3.2	2.7	2.0	1.1	2.0	13.4	6.0
O	9	2.2	2.2	9.3	13.1	11.2	10.7	10.5	9.9	7.5	6.5	5.8	3.4	2.4	2.2	1.0	1.9	13.6	6.1
	12	1.9	1.2	9.1	10.6	10.0	8.5	8.4	8.5	9.3	8.2	7.3	4.4	3.9	3.5	2.6	2.6	15.2	6.8
U	15	1.5	1.4	7.8	10.8	11.2	9.1	7.5	6.9	8.2	7.9	7.8	4.5	5.4	3.7	2.7	3.7	15.9	7.1
	18	1.8	1.4	9.1	13.1	13.0	11.4	9.3	8.9	7.9	6.4	5.9	3.2	2.9	2.2	1.6	1.7	13.7	6.1
R	21	1.9	1.6	8.8	15.3	12.5	12.4	10.1	8.8	8.3	7.2	4.3	2.5	1.9	1.7	1.1	1.7	13.0	5.8
	24	2.1	1.6	10.1	14.5	10.6	13.0	9.6	8.4	9.4	5.7	4.9	3.4	2.1	2.1	0.8	1.5	13.0	5.8
ALL HOURS		2.1	1.5	9.3	12.8	11.5	11.0	9.4	8.5	8.7	6.9	5.8	3.4	3.0	2.5	1.5	2.0	13.9	6.2

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 18
Percentage Frequency Summary For Wind Speed
CASCADE COUNTY - GREAT FALLS NWS AIRPORT (SPRING)
01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	AV SPEED (MPH)	AV SPEED (M/SEC)
		WIND SPEED (M/SEC)																	
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2		
H	3	3.2	2.3	9.9	17.3	20.8	17.5	9.6	7.6	5.7	3.1	1.4	0.6	0.5	0.3	0.0	0.3	10.2	4.6
	6	3.4	2.5	12.0	18.5	17.5	14.3	11.3	8.5	5.3	2.7	2.3	1.0	0.4	0.3	0.2	0.0	10.1	4.5
O	9	2.5	2.0	10.7	13.7	13.1	12.4	12.0	9.4	8.8	6.0	4.8	1.8	1.4	1.0	0.1	0.3	12.0	5.4
	12	1.3	1.4	10.0	12.8	11.9	12.2	8.6	9.3	9.2	6.6	6.2	2.9	3.0	2.6	0.7	1.5	13.6	6.1
U	15	0.8	1.4	7.0	12.0	12.8	14.2	7.5	9.9	9.4	7.7	5.6	3.4	3.0	2.7	0.8	1.8	14.2	6.4
	18	1.2	1.3	6.2	10.0	14.3	13.3	10.9	11.5	8.0	7.7	5.8	3.3	2.4	2.1	0.9	1.0	13.9	6.2
R	21	1.2	1.2	10.7	17.2	19.4	16.9	11.6	8.0	6.7	3.0	2.3	0.7	0.4	0.4	0.0	0.3	10.7	4.8
	24	1.9	2.5	9.9	19.0	19.2	19.4	9.5	7.1	5.7	3.2	1.3	0.5	0.4	0.3	0.0	0.2	10.2	4.6
ALL HOURS		2.0	1.8	9.5	15.1	16.1	15.0	10.1	8.9	7.4	5.0	3.7	1.8	1.4	1.2	0.3	0.7	11.9	5.3

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 19
Percentage Frequency Summary For Wind Speed
CASCADE COUNTY - GREAT FALLS NWS AIRPORT (SUMMER)
01/01/65 - 12/31/78

		WIND SPEED (MPH)																		
		<0.5	0.5- 1.4	1.5- 2.4	2.5- 3.4	3.5- 4.4	4.5- 5.4	5.5- 6.4	6.5- 7.4	7.5- 8.4	8.5- 9.4	9.5- 10.4	10.5- 11.4	11.5- 12.4	12.5- 13.4	13.5- 14.4	>14.4			
		WIND SPEED (M/SEC)																	AV SPEED (MPH)	AV SPEED (M/SEC)
		<1.1	1.1- 3.1	3.4- 5.4	5.6- 7.6	7.8- 9.8	10.1- 12.1	12.3- 14.3	14.5- 16.6	16.8- 18.8	19.0- 21.0	21.3- 23.3	23.5- 25.5	25.7- 27.7	28.0- 30.0	30.2- 32.2	>32.2			
H	3	3.1	1.6	14.2	27.9	25.3	13.7	6.9	4.1	2.1	0.7	0.5	0.0	0.0	0.0	0.0	0.0	8.2	3.7	
	6	3.7	2.1	15.8	26.3	25.9	14.0	5.2	3.5	1.7	1.0	0.5	0.2	0.0	0.1	0.0	0.0	8.0	3.6	
O	9	1.8	2.1	13.8	20.2	19.7	14.3	10.3	5.4	5.7	3.2	1.9	0.7	0.3	0.6	0.0	0.0	10.0	4.5	
	12	1.3	1.2	11.1	20.3	20.4	14.1	9.5	7.2	5.4	3.6	2.4	0.6	1.7	0.9	0.1	0.1	10.6	4.7	
U	15	0.6	1.0	9.4	16.0	20.7	15.8	9.6	7.8	7.3	3.6	3.4	1.7	1.3	0.8	0.6	0.3	11.5	5.2	
	18	1.1	1.0	8.1	14.4	17.9	16.7	11.1	9.7	7.1	4.3	3.6	2.2	1.4	0.8	0.6	0.3	12.1	5.4	
R	21	1.4	1.5	9.3	22.9	24.2	18.1	10.1	4.8	3.9	2.1	1.2	0.2	0.2	0.1	0.0	0.1	9.6	4.3	
	24	1.2	1.6	11.3	28.3	27.3	17.3	6.1	4.3	1.4	0.7	0.2	0.2	0.1	0.2	0.0	0.0	8.6	3.8	
ALL HOURS		1.8	1.5	11.6	22.0	22.7	15.5	8.6	5.9	4.3	2.4	1.7	0.7	0.6	0.4	0.1	0.1	9.8	4.4	

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Table IV - 20
Percentage Frequency Summary for Wind Speed
CASCADE COUNTY - GREAT FALLS NWS AIRPORT (AUTUMN)
01/01/65 - 12/31/78

		WIND SPEED (MPH)																	
		<0.5	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-5.4	5.5-6.4	6.5-7.4	7.5-8.4	8.5-9.4	9.5-10.4	10.5-11.4	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	AV	AV
		WIND SPEED (M/SEC)																SPEED	SPEED
		<1.1	1.1-3.1	3.4-5.4	5.6-7.6	7.8-9.8	10.1-12.1	12.3-14.3	14.5-16.6	16.8-18.8	19.0-21.0	21.3-23.3	23.5-25.5	25.7-27.7	28.0-30.0	30.2-32.2	>32.2	(MPH)	(M/SEC)
H	3	2.7	2.0	9.6	17.0	19.9	14.4	12.1	7.5	5.9	2.8	2.7	0.9	0.9	0.9	0.4	0.4	10.8	4.8
	6	2.1	1.5	10.2	17.8	16.6	16.1	10.9	9.2	6.4	3.4	2.8	1.2	0.6	0.6	0.2	0.3	11.0	4.9
O	9	2.7	1.4	9.0	16.9	13.7	15.0	9.8	9.5	8.2	5.5	2.6	2.4	1.2	1.2	0.5	0.4	11.8	5.3
	12	1.7	1.5	8.0	11.2	11.1	11.0	9.4	9.2	10.8	6.7	6.1	4.2	3.3	3.5	1.3	1.0	14.4	6.4
U	15	0.8	0.8	7.2	11.3	12.2	11.2	9.9	9.0	10.0	7.0	7.8	4.0	3.3	2.8	1.2	1.5	14.7	6.6
	18	0.7	0.9	6.4	14.8	17.0	14.4	11.4	9.5	8.5	5.6	3.5	2.8	1.7	1.5	0.7	0.4	12.7	5.7
R	21	1.0	1.4	7.2	16.3	21.9	17.7	10.2	8.9	6.2	4.2	2.3	0.9	0.6	0.6	0.3	0.2	11.2	5.0
	24	1.7	1.2	8.8	18.0	20.1	17.7	10.0	8.2	4.9	3.4	2.9	1.2	0.7	0.7	0.3	0.3	11.0	4.9
ALL HOURS		1.7	1.3	8.3	15.4	16.6	14.7	10.5	8.9	7.6	4.9	3.8	2.2	1.5	1.4	0.6	0.6	12.2	5.4

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

DIRECTION>		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	<DIRECTION	
SPEED (MPH)																			SPEED (M/SEC)	
SPEED	1.1- 3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5- 1.4	
	3.4- 5.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	1.6	1.5- 2.4	
	5.6- 7.6	0.7	0.5	0.5	0.5	0.8	0.7	0.5	0.3	0.7	0.6	0.8	0.8	0.9	0.5	0.4	0.5	9.7	2.5- 3.4	
	7.8- 9.8	1.0	0.7	1.0	0.9	1.3	0.9	0.6	0.3	1.0	1.2	2.0	1.7	1.4	0.7	0.8	0.9	16.4	3.5- 4.4	
	10.1-12.1	0.9	0.6	0.9	0.9	1.0	0.6	0.3	0.2	1.0	1.9	2.9	1.8	1.3	0.8	0.8	0.8	16.7	4.5- 5.4	
	12.3-14.3	0.6	0.4	0.6	0.6	0.5	0.2	0.1	0.1	0.7	1.9	3.5	1.7	1.1	0.7	0.7	0.6	14.0	5.5- 6.4	
	14.5-16.6	0.3	0.2	0.3	0.2	0.2	0.1	0.0	0.0	0.4	1.6	3.1	1.2	0.7	0.4	0.4	0.4	9.5	6.5- 7.4	
	16.8-18.8	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.3	1.2	2.8	1.3	0.6	0.3	0.4	0.4	8.1	7.5- 8.4	
	19.0-21.0	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3	1.1	2.7	1.2	0.6	0.2	0.2	0.3	7.0	8.5- 9.4	
	21.3-23.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	2.1	0.9	0.4	0.1	0.1	0.1	4.6	9.5-10.4
MILE	23.5-25.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	1.7	0.8	0.3	0.1	0.1	0.1	3.7	10.5-11.4
	25.7-27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.0	0.4	0.2	0.0	0.0	0.0	1.8	11.5-12.4	
	28.0-30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.4	0.1	0.0	0.0	0.0	1.5	12.5-13.4	
	30.2-32.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	0.3	0.1	0.0	0.0	0.0	1.3	13.5-14.4	
	32.4-34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.2	0.1	0.0	0.0	0.0	0.8	14.5-15.4	
	34.7-36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.3	15.5-16.4	
	36.9-38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	16.5-17.4	
	39.1-41.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	17.5-18.4	
	41.4-43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5-19.4	
	43.6-45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5-20.4	
SOUND	45.9-56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5-25.4	
	57.0-68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5-30.4	
	68.2-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5-35.4	
	79.4-90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5-40.4	
	>90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	>40.4	
	CALM																		1.9	CALM
	TOTAL	4.2	2.6	3.7	3.3	4.0	2.6	1.6	1.0	4.8	11.5	25.2	12.9	8.0	3.9	4.3	4.4	99.9	TOTAL	
	AV SPD (MPH)	9.2	8.5	8.7	8.3	7.6	6.9	6.5	6.7	10.1	13.0	15.7	14.1	11.9	10.3	10.7	10.5	9.9	AV SPD (MPH)	
	AV SPD (M/S)	4.1	3.8	3.9	3.7	3.4	3.1	2.9	3.0	4.5	5.8	7.0	6.3	5.3	4.6	4.8	4.7	4.4	AV SPD (M/S)	

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

Figure IV - 2
Annual Wind Rose
GREAT FALLS NWS AIRPORT— CASCADE COUNTY
(1965 - 1978)

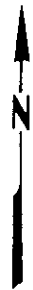
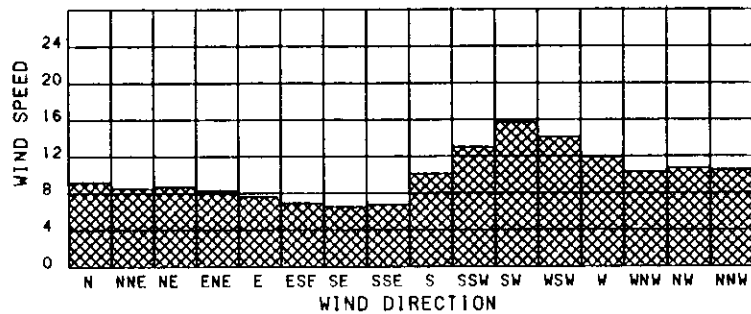
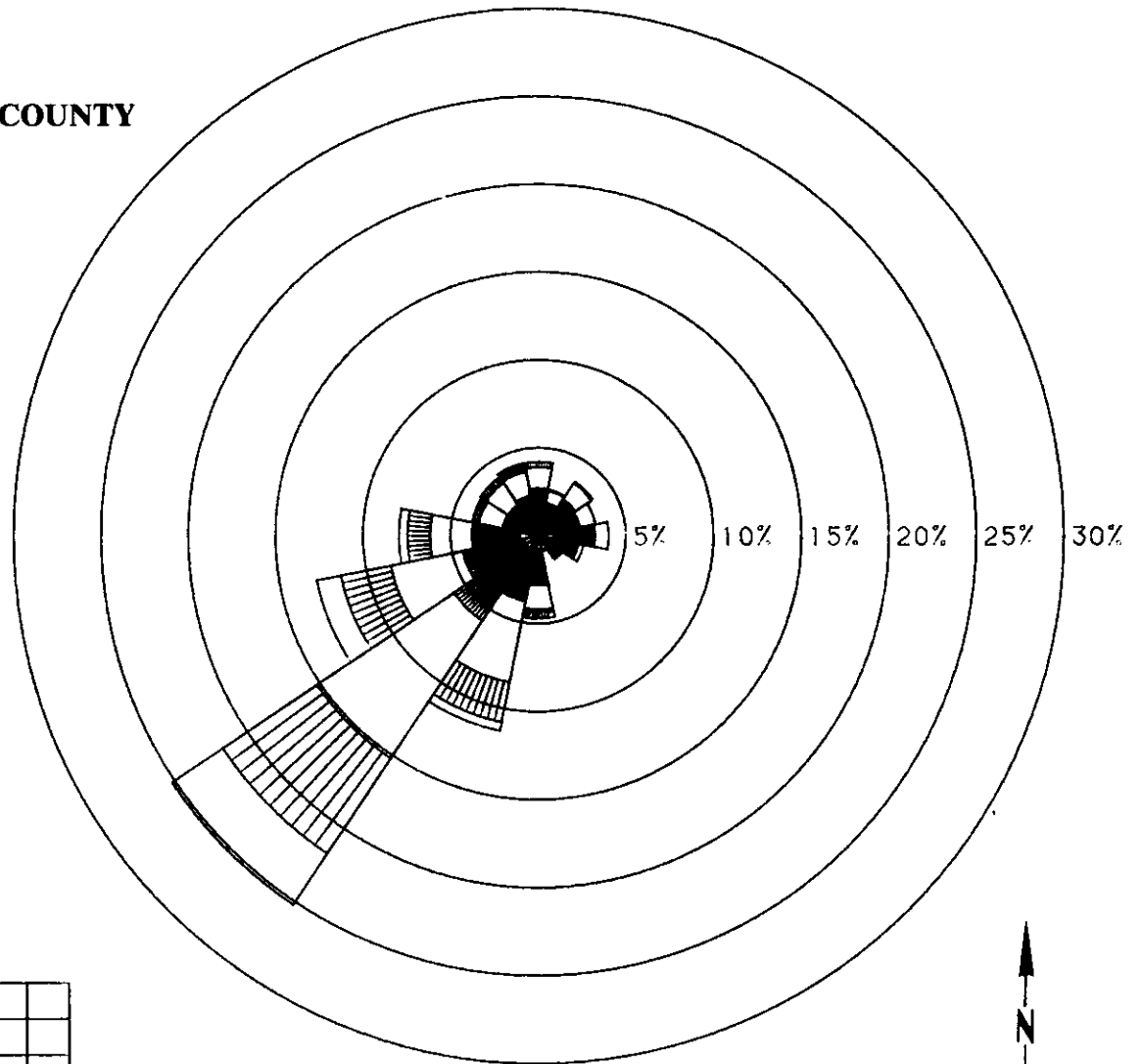
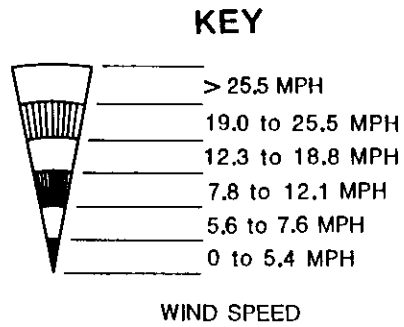


Table IV - 22
Coefficients of Weibull Distribution
CASCADE COUNTY - GREAT FALLS NWS AIRPORT
01/01/65 - 12/31/78

MONTH	SCALE FACTOR (C) (M/SEC)	SHAPE FACTOR (K)
JANUARY	7.3360	1.9960
FEBRUARY	7.4020	2.1990
MARCH	7.0660	2.0710
APRIL	6.5430	2.2810
MAY	6.2960	2.3180
JUNE	5.9260	2.3470
JULY	5.6600	2.4930
AUGUST	5.7710	2.4570
SEPTEMBER	6.1400	2.5050
OCTOBER	7.1040	2.5040
NOVEMBER	7.2100	2.1150
DECEMBER	7.8730	2.1590
YEAR	6.7150	2.2100

SOURCE: BATTELLE PACIFIC NORTHWEST LABORATORIES

SALEM

CASCADE COUNTY

The Salem site is located 1 mile south of the Missouri River and about 15 miles east of Great Falls at 47 34 22 N and 111 02 34 W (Site No. 17 on Map II-1). Elevation at the site is 3,250 feet. The site was established by the Montana Power Company to measure background meteorological and air quality conditions for the company's proposed Salem project.

Wind data were collected from May 1980 through March 1984. Data from May 1, 1980 through October 31, 1981, were available for analysis for the first edition of the *Atlas*. The data set contains hourly averages of:

- Wind speed and direction at 10, 30, and 100 meters above ground level;
- Standard deviation of wind direction at 100 meters;
- Average vertical wind direction at 100 meters;
- Temperature at 10, 30, and 100 meters;
- Stability based on actual lapse rate of temperature with height.

The data were recorded by a data acquisition system that scanned each parameter every 30 seconds. All the electronic meteorological sensors were manufactured by Met One, Inc., and were mounted on a 100-meter tower. Winds were monitored long enough to adequately represent the wind resource at this location. The data are representative of the wind resource in the Great Falls area at relatively high and exposed sites.

Data recovery at the 10-meter level was excellent, ranging from 94.5 percent in January to 99.4 percent in April. Overall data recovery was 97.9 percent. Average annual wind speed was 10.2 miles per hour. Average monthly wind speed values ranged from 8.0 miles per hour in January to 14.3 miles per hour in December. Average annual wind power was 139.7 watts/m² and ranged from 50.5 watts/m² in August to 457.8 watts/m² in December.

At the 30-meter level, average annual wind speed was 11.9 miles per hour, with monthly average speeds ranging from 9.1 miles per hour in August to 16.3 miles per hour in December. Average annual wind power at this level was 214.6 watts/m², with a low monthly average of 79.2 watts/m² in August and a high monthly average of 671.5 watts/m² in December.

At the 100-meter level, wind speeds averaged 14.5 miles per hour on an annual basis, with an August low of 10.7 miles per hour and a November high of 20.8 miles per hour. Average annual wind power at this level was 379.4 watts/m², with average monthly values ranging from 127.9 watts/m² in August to 1041.2 watts/m² in December.

Further analysis of this site is presented in Chapter V.

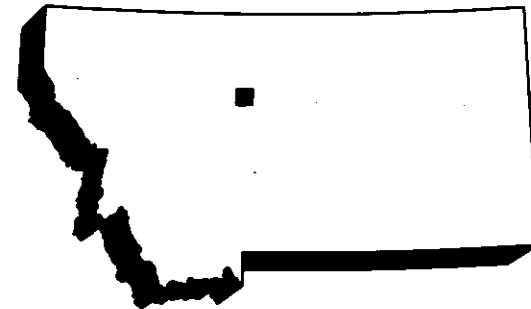


Table IV - 23
Monthly Wind Speed Distribution
CASCADE COUNTY - SALEM
05/01/80 - 10/31/81

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
CALM	0.6	0.0	0.4	0.3	0.2	0.2	0.6	0.0	0.0	0.0	0.0	0.5	0.2	CALM
1.3- 2.2	14.2	5.7	10.0	7.0	6.7	3.9	6.1	6.7	7.1	6.2	4.9	8.1	6.9	0.6- 1.5 S
S 3.6- 5.6	21.5	14.3	23.2	11.5	24.3	17.7	22.1	28.5	22.8	14.2	10.6	21.1	20.1	1.6- 2.5 P
P 5.8- 7.8	17.6	12.8	20.8	9.6	20.1	20.6	23.2	26.9	18.7	15.9	14.1	15.2	19.0	2.6- 3.5 E
E 8.1-10.1	18.3	12.0	17.1	12.7	16.0	17.0	16.7	16.3	14.8	18.1	11.3	7.0	15.4	3.6- 4.5 E
E 10.3-12.3	12.1	9.0	9.6	12.0	11.3	12.1	9.3	8.5	9.9	13.2	11.0	3.8	10.3	4.6- 5.5 D
D 12.5-14.5	6.3	5.4	5.9	10.1	8.8	7.6	5.9	5.0	6.6	9.9	9.7	3.4	7.1	5.6- 6.5
14.8-16.8	4.3	5.4	1.9	9.1	5.8	7.7	6.4	2.9	5.9	5.9	6.6	2.7	5.5	6.6- 7.5 M
M 17.0-19.0	2.2	5.9	4.9	7.7	3.2	6.3	3.2	1.8	4.0	3.8	6.1	3.1	4.1	7.6- 8.5 /
P 19.2-25.7	2.6	18.3	6.1	12.0	3.3	5.3	5.7	3.1	8.0	10.2	16.2	15.4	7.8	8.6-11.5 S
H 25.9-30.2	0.3	6.5	0.1	5.9	0.4	0.8	0.7	0.2	2.1	1.9	6.3	9.5	2.2	11.6-13.5 E
30.4-34.7	0.0	2.7	0.0	2.1	0.0	0.6	0.1	0.1	0.1	0.6	2.3	5.4	0.9	13.6-15.5 C
34.9-39.1	0.0	1.8	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.8	3.7	0.4	15.6-17.5
>39.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.9	0.1	>17.5
AVERAGE														
SPEED (MPH)	8.0	13.8	8.6	13.0	8.7	10.1	9.0	7.8	9.8	10.9	13.6	14.3	10.2	
AVERAGE														
SPEED (M/SEC)	3.6	6.2	3.8	5.8	3.9	4.5	4.0	3.5	4.4	4.9	6.1	6.4	4.6	
AVERAGE														
WIND POWER														
(WATTS/M**2)	59.4	325.7	77.9	234.6	67.5	104.5	79.9	50.5	110.6	140.8	278.3	457.8	139.7	
PERCENT DATA														
RECOVERY	94.5	99.1	98.4	99.4	96.8	98.9	99.3	98.6	97.4	96.0	98.5	99.2	97.9	

ANEMOMETER HEIGHT = 10 METERS = 33 FEET

NUMBER OF OBSERVATIONS = 12927

PERCENTAGE DATA RECOVERY = 97.9

SOURCE: GEORESEARCH, INC.

Table IV - 24
Monthly Average Wind Speed and Wind Power Density (30 Meters)
CASCADE COUNTY - SALEM
05/01/80 - 10/31/81

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
AVERAGE SPEED (MPH)	9.4	16.1	9.6	15.0	10.2	12.0	10.7	9.1	11.4	12.9	16.2	16.3	11.9
AVERAGE SPEED (M/SEC)	4.2	7.2	4.3	6.7	4.6	5.4	4.8	4.1	5.1	5.8	7.2	7.3	5.3
AVERAGE WIND POWER (WATTS/M*2)	95.0	489.0	108.3	347.9	106.5	166.5	125.7	79.2	171.1	226.2	432.7	671.5	214.6
PERCENT DATA RECOVERY	97.6	99.1	95.2	99.4	96.8	97.2	99.3	98.6	97.4	96.0	98.5	99.2	97.7

SOURCE: GEORESEARCH, INC.

Table IV - 25
Monthly Average Wind Speed and Wind Power Density (100 Meters)
CASCADE COUNTY - SALEM
05/01/80 - 10/31/81

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
AVERAGE SPEED (MPH)	12.7	20.3	12.1	18.1	11.8	14.6	12.7	10.7	13.8	16.4	20.8	17.5	14.5
AVERAGE SPEED (M/SEC)	5.7	9.1	5.4	8.1	5.3	6.5	5.7	4.8	6.2	7.3	9.3	7.8	6.5
AVERAGE WIND POWER (WATTS/M*2)	240.0	958.4	223.8	583.1	169.1	292.8	216.6	127.9	306.2	441.9	857.1	1041.2	379.4
PERCENT DATA RECOVERY	97.6	99.1	98.4	99.3	96.8	97.2	99.3	98.6	97.4	96.0	98.5	86.1	97.0

SOURCE: GEORESEARCH, INC.